REMARKS/ARGUMENTS

The examiner is thanked for thoroughly reviewing the subject patent application. Applicants wish to point out the major features of their claimed invention, which is an MTJ type MRAM device (and an array of such devices) in which a magnetic anisotropy is provided to a ferromagnetic free layer of small circular cross-section by means of an antiferromagnetic layer that is formed over it and exchange coupled to it.

As is discussed within the subject application, many of the problems associated with the construction of MRAM arrays are related to the continually decreasing dimensions of the individual cell elements. In particular, as the cross-sectional area of an MRAM MTJ type cell free layer becomes smaller, a stable domain structure is difficult if not impossible to maintain and an intrinsic (ie., a crystalline) magnetic anisotropy cannot be built into the cell as its free layer is formed. Without a magnetic anisotropy the cell cannot maintain a stable directional magnetic moment and, thereby, efficiently store data. Since the size of the cell free layer does not permit a crystalline or intrinsic magnetic anisotropy, an alternative approach is to give the layer a shape anisotropy. In other words, by forming the cell with a non-circular cross-section, such as an elliptical or lozenge shaped cross-section, the shape can provide a degree of anisotropy even when an intrinsic anisotropy is absent. As a result, cell shapes of present designs are typically single element rectangle, elliptical or lozenge. Unfortunately, such non-symmetric shapes lead to their own set of problems. In particular, any irregularities in these shapes,

which are more difficult to form than circular shapes, or any defects at their edges produced during their formation, will result in coercivity fluctuations distributed throughout the array. Therefore, an alternative approach is developed in the present claimed invention, namely to provide magnetic anisotropies in MRAM MTJ type cells without the necessity of utilizing shapes that are difficult to fabricate, but by forming a ferromagnetic layer on an antiferromagnetic layer. In this way, a magnetic exchange coupling can be produced between the ferromagnetic and antiferromagnetic layers that will provide the required magnetic anisotropy. It is the object of the present claimed invention to utilize the exchange coupling properties of antiferromagnetic layers with ferromagnetic layers to provide the necessary magnetic anisotropy to form an MTJ memory cell of small size that is capable of advantageously storing data without the necessity of obtaining the anisotropy through the route of shape anisotropy.

In accord with this object, the cell shape can be circular, which is a particularly simple shape to fabricate and whose shape variations can be easily controlled. In fact, for small enough dimensions, a simple square mask design will almost necessarily create a substantially circular cell pattern. The success of the method is based on the fact that a very thin antiferromagnetic material layer grown on a ferromagnetic material layer can render the magnetization of the ferromagnetic layer effectively magnetically anisotropic within the plane of its formation by means of exchange coupling across the interface between the two layers. The claimed method, as in claim 1, proposes that a ferromagnetic free layer of an MTJ device be formed, with a circular shape, beneath a "top" thin antiferromagnetic layer. Although the circular shape will provide no shape anisotropy and although the small size of the free layer will provide no crystalline

anisotropy, the top antiferromagnetic layer formed on the free layer will provide an anisotropic exchange coupling. Since no shape anisotropy is required, the MTJ cell can be formed with dimensions less than 0.3 microns using even a square mask design, which at such small dimensions will produce a patterned cell that is substantially circular. The free layer can be a single layer of ferromagnetic material or it can be formed as a synthetic ferromagnetic layer with a top layer of antiferromagnetic material. The magnetization of the top antiferromagnetic layer will be set in the same direction as the bottom antiferromagnetic layer that pins the fixed ferromagnetic layer of the MTJ device. The magnetizations will be set in the same magnetic field and at the same temperature.

Having thus briefly explained the invention, Applicants would like to address the specific objection of the Patent Examiner.

Provisional Claim Rejections Under Obviousness-Type Double Patenting.

Applicants respectfully request the reconsideration of the rejection of claims 1, 3-5 and 8-10 as being unpatentable over claims 17, 21, 23, 29 and 30 in co-pending Application No. 10/872,915, assigned to the same assignee as the present application. Applicants would respectfully argue that the conflicting claims are patentably distinct from each other and that, therefore, they do not warrant a rejection under the judicially created doctrine of obviousness-type double patenting. Applicants would also respectfully request that the remaining claims 2, 6, 7 and 11-14, which are objected to, are also allowable as depending from allowable claims.

The invention claimed in claims 17, 21, 23, 29 and 30 in co-pending Application No. 10/872,915 is for an MTJ MRAM cell formed at the intersection of word and bit

lines, wherein the bit line includes a soft adjacent magnetic layer or "SAL," which is a layer of low coercivity magnetic material formed on the bit line surface adjacent to the MRAM cell element. The cell element itself does not include the antiferromagnetic layer coupled to a free layer that is the present claimed invention. Indeed, the cell claimed in claims 17 and 21 of co-pending Application 10/872,915 has no internal mechanism for providing its free layer with the magnetic anisotropy provided by the exchange coupled antiferromagnetic layer of the present claimed invention. Indeed, claim 17 of the co-pending application does not recite a cell with either crystalline or shape anisotropy, requiring only that the cell be circular or elliptical with a small aspect ratio. Claim 21 of the co-pending application recites a cell that does not have an antiferromagnetic layer coupled to its free layer. Claim 29 of the co-pending Application recites that the cell can be formed in an asymmetric shape to provide shape anisotropy. The invention claimed in the co-pending application attains an advantageous operation of an MRAM cell not by a magnetic anisotropy in the cell itself, as is the case in the present claimed invention, but by a soft magnetic layer formed on the bit line that passes above the cell. In short, the present claimed invention claims a cell with a novel structure, the co-pending application claims a bit line with a novel structure. The present claimed invention achieves a magnetic anisotropy by exchange coupling a free layer (within the cell) to an antiferromagnetic layer (within the cell). The invention claimed in the co-pending application does not include an antiferromagnetic layer exchange coupled to a cell free layer. Instead, it includes a soft magnetic layer on a bit line that is external to the cell. The external soft magnetic layer does, in fact, couple to the free layer within the cell, but

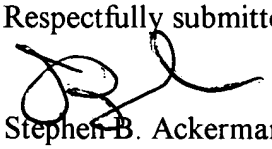
it is a different form of magnetic coupling and is not equivalent to the magnetic anisotropy produced within the cell itself by the present claimed invention.

Applicants would respectfully suggest that claim 1 of the present claimed invention, which recites a top layer of antiferromagnetic material that is exchange coupled to a ferromagnetic free layer beneath it by an annealing process, is patentably distinct from claim 17 of the co-pending application which does not recite such a coupled combination. Conversely, the invention claimed in the present application does not recite a bit line with an SAL, as is claimed in the co-pending application. Applicants would further respectfully argue that the present claimed invention is not suggested by the invention in the co-pending application and, therefore, that the present claims 1-14 do not constitute double-patenting.

Conclusion

The Examiner is thanked for thoroughly reviewing the application. All claims discussed above are now believed to be allowable. If the Examiner has any questions regarding the above application, please call the undersigned attorney at 845-452-5863

Respectfully submitted,



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